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### Pacing in Olympic track races: Competitive tactics versus best performance strategy

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## Pacing in Olympic track races: Competitive tactics versus best performance strategy

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### Abstract

The purpose of this study was to describe pacing strategies in the 800 to 10,000-m Olympic finals. We asked 1) if Olympic finals differed from World Records, 2) how variable the pace was, 3) whether runners faced catastrophic events, and 4) for the winning strategy.

Publically available data from the Beijing 2008 Olympic Games gathered by four transponder antennae under the 400-m track were analysed to extract descriptors of pacing strategies. Individual pacing patterns of 133 finalists were visualised using speed by distance plots.

Six of eight plots differed from the patterns reported for World Records. The coefficient of running speed variation was 3.6–11.4%. In the long distance finals, runners varied their pace every 100 m by a mean 1.6–2.7%. Runners who were ‘dropped’ from the field achieved a stable running speed and displayed an endspurt. Top contenders used variable pacing strategies to separate themselves from the field. All races were decided during the final lap.

Olympic track finalists employ pacing strategies which are different from World Record patterns. The observed micro- and macro-variations of pace may have implications for training programmes. Dropping off the pace of the leading group is an active step, and the result of interactive psychophysiological decision making.

**Keywords:** *athletic performance, competitive behaviour, running, track and field, physical endurance*

### Introduction

Pacing strategy is an important determinant of success in sports competitions (Abbiss & Laursen, 2008; Foster, Schrager, Snyder, & Thompson, 1994; Tucker & Noakes, 2009). Athletes have to distribute their ability to provide for muscular adenosine triphosphate (ATP) generation while maintaining an adequate reserve (Swart et al., 2009a, 2009b) such that the athlete neither runs out of energy and faces catastrophic physiological failure before the finish, nor has excess energetic reserves at the end of the competition. This is probably a learned pattern, or a pacing template, based on extensive experience gained during training and previous competitions (Foster et al., 2009, 2012; Micklewright, Papadopoulos, Swart, & Noakes, 2010).

In long-distance running events, most of the literature on pacing is either on World Record performances (Tucker, Lambert, & Noakes, 2006) or on sub-elite-standard runners running at their own

best pace (Abbiss & Laursen, 2008; Faulkner, Parfitt, & Eston, 2008; Lima-Silva et al., 2009). The dominant ‘best race’ strategy in 800-m middle-distance running is thought to be a small but progressive slowing (Tucker et al., 2006). In 1.5–10-km track races, the best race strategy has been described as even pacing with an endspurt (Tucker et al., 2006).

However, in high-standard competitions, the finishing place is a more important outcome than finishing time. Top runners might run with a slower than ideal pace with varied tactics, and variations in pace can vary with the overall pace of the race. Also, less accomplished runners can feel forced to stay with the leading group at a pace markedly faster than their best performance. This increases the risk of premature excessive fatigue that could result in a decisive and progressive decrease in pace.

Unfortunately, there are few data on ways in which races at world-class championships are actually contested. Split times have been available only for 400-m segments, so the temporal resolution of

pacing data has been inadequate to reveal the behaviour of athletes during competition.

Timing data from the 2008 Olympiad have now become publically available ([www.iaaf.org](http://www.iaaf.org)) with a resolution of 100 m, which allows an examination of how world-standard races are contested. With the availability of this unique data set, we addressed several basic questions:

1. Do the pacing strategies in middle- and long-distance track events (800–10,000 m) at Olympic finals differ from World Record pacing?
2. How 'constant' is running speed during the middle portions of long-distance events? Do the traditionally used 400-m split times represent the same variation in running speed as 100-m splits?
3. Is there evidence of a 'catastrophic event' in runners who drop off the leading group in the 5- or 10-km races? Do these runners run at a progressively slower pace throughout the event, or do they simply decrease their pace to a more individually appropriate level and then display a normal pacing pattern?
4. What is the winning strategy of the medallists over non-medallists (places 4–8) and finalists (places 9+)? Is the winning strategy among medallists dependent on forcing the following runners to 'drop back' during the event or on a better endspurt?

## Methods

Split times from the men's and women's 800-m, 1500-m, 5-km and 10-km finals from the 2008 Beijing Olympic Games, which are publically available on the website of the International Association of Athletics Federations (IAAF) ([www.iaaf.org](http://www.iaaf.org)) were analysed. In Beijing, the IAAF used a new system provided by Swiss Timing Sportservice GmbH (Leipzig, Germany). The system comprises a transponder antennae under the 400-m track at 0 m, 100 m, 200 m and 300 m, and ID chips on the inside of each athlete's front bib. When athletes pass over the transponder, their ID is read from the chip and their time registered to the nearest tenth of a second. In the women's 5-km final, one of the timing markers did not function. Accordingly, 100-m data were calculated based on the measured 200-m time for this segment, with the two adjacent 100-m segments assumed to be at the same pace.

Analysis was completed in four ways. First, individual plots of speed by distance allowed visual comparison of the pattern of pacing for each individual runner with the recent World Record as published in the IAAF book of world records (International Amateur Athletic Federation, 2007).

Also, the relative speed of the second versus the first half of the race was calculated in medallists (places 1–3), non-medallists (places 4–8), and finalists (places 9+) and compared with recent World Records to indicate whether the overall pacing pattern was positive, even, or negative. Second, intra-individual coefficients of variation of running speed were calculated based on 100-m, 400-m and 1000-m split times as applicable, and compared to recent World Records. Also, the absolute value of the individual relative change in pace for every 100 m was calculated to improve the sensitivity of pace variation. Furthermore, plots of the mean speed of all finalists were compared at resolutions of 100 m versus 400 m. Third, in the long-distance races, the largest decrease of speed between any two 100-m segments in the second half of the race was calculated for medallists, finalists (places 4+) and runners who slowed down (>3% decrease of speed in the second half of the race) to detect possible catastrophic events. In the same groups, running speed in the last lap was reported normalised to the speed in the last quarter to compare runners' reserves for an endspurt. Fourth, individual data were collapsed into groups of medallists, non-medallists, and finalists to allow visualisation of the pacing pattern in competitively meaningful groups of runners, and speed-by-distance plots of the three medallists were constructed.

Because these data represent unique observations, the analysis was fundamentally descriptive, and no conventional statistical analyses were used.

## Results

All of the events were won in a time within 4% of the World Record, except the women's 5 km, which was run in a particularly tactical manner. Bronze medallists were within 2% of the race winner, and in all races except the women's 10 km, the last finisher was within 10% of the winner (Table I).

Plots of running speed versus distance show that in all races except the women's 800 m and 10 km, the individual patterns of speed in Olympic finals differed from the World Record (Figures 1 and 2). The overall pacing patterns (1st versus 2nd half) were also different (Table II). In the 5- and 10-km races, runners who were 'dropped' from the field appeared to achieve a stable running speed, and increased their speed on the last 400 m.

Runners varied their speed every 100 m by a mean 1.6–2.7%, even in fast races or after they had been dropped off. Coefficients of variation in running speed were higher based on 100-m rather than 400-m split times, and for most runners higher in the Olympic finals than in World Records (Table III). Plotting mean running speed based on 100-m splits yielded additional information on the pacing pattern

Table I. Performance times in Beijing Olympic finals.

Race	Number of Finishers	Winning Time	Winning Time (% vs. World Record)	Bronze Medal Time (% vs. Winning Time)	Last Finisher Time (% vs. Winning Time)
M 800 m	8	1:44.65	103.5	100.2	102.4
W 800 m	8	1:54.87	101.4	101.6	106.8
M 1500 m	12	3:32.94	103.4	100.6	103.3
W 1500 m	12	4:00.23	104.2	100.6	102.9
M 5 km	14	12:57.82	102.7	101.1	107.4
W 5 km	15	15:41.40	110.6	100.3	109.1
M 10 km	35	27:01.17	102.8	100.2	108.9
W 10 km	29	29:54.66	101.3	101.5	111.3

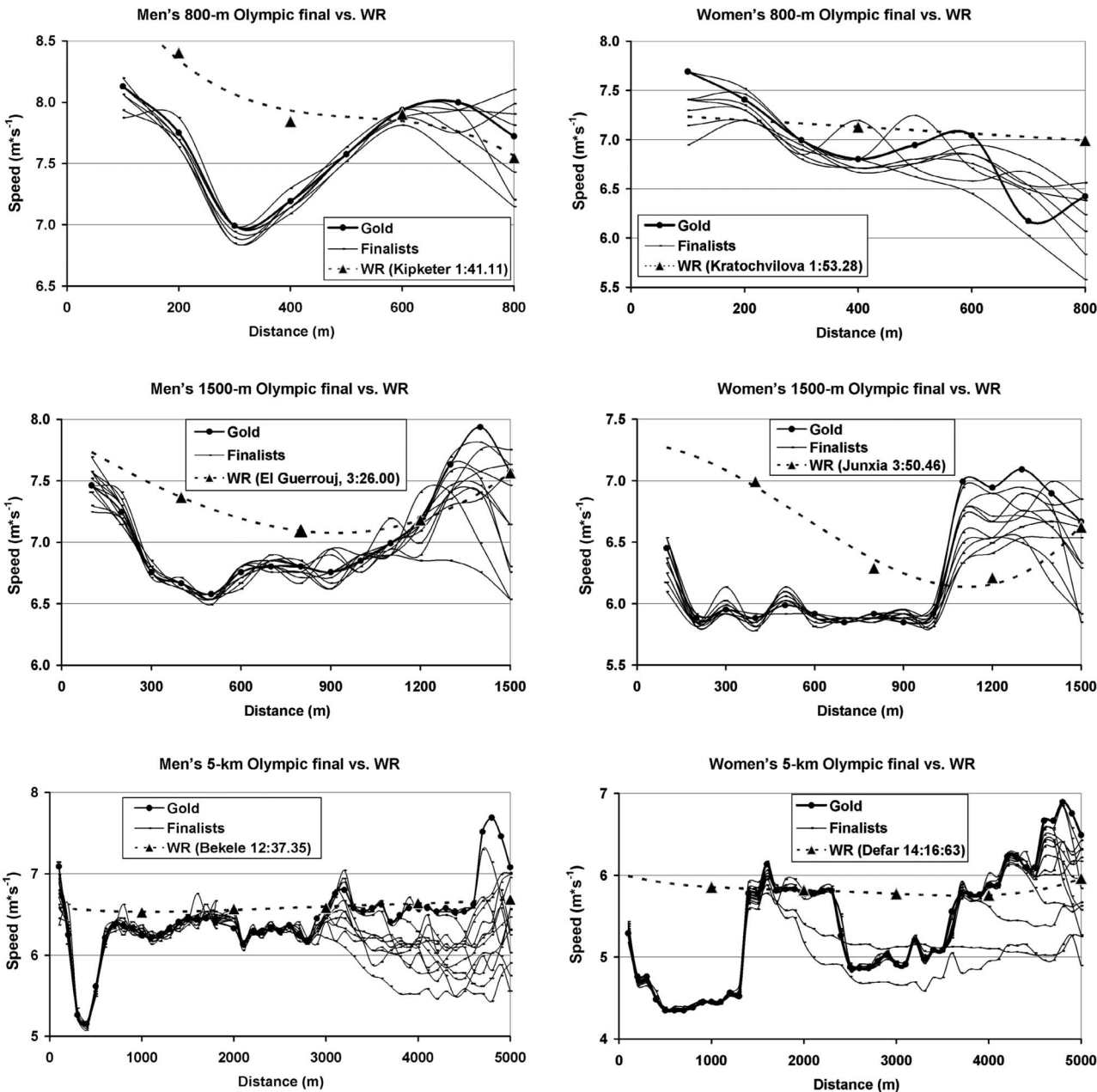


Figure 1. Pacing strategy of Olympic 800- to 5000-m finalists compared with the world record.



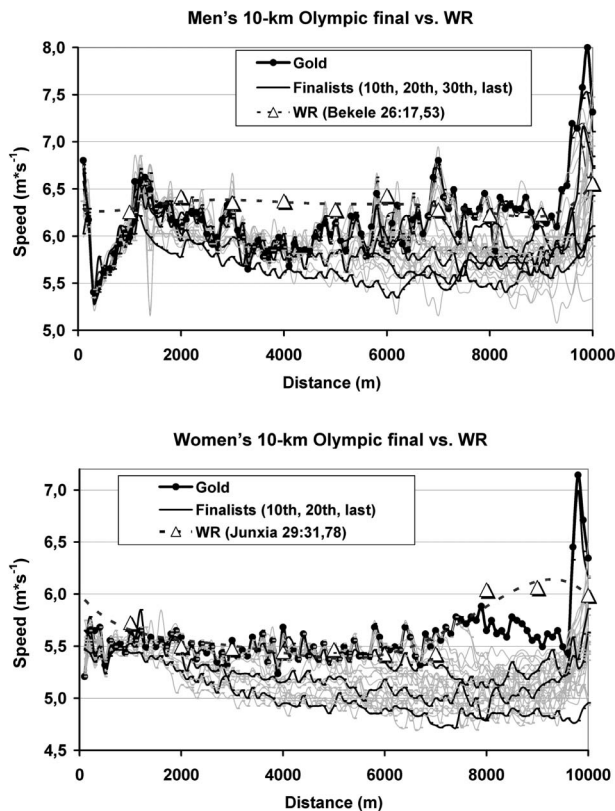


Figure 2. Pacing strategy of Olympic 10-km finalists compared with the world record.

Table II. Mean relative speed in the second versus the first half of the race in world records (WR) achieved 1983–2008, and in the 2008 Beijing Olympic finals.

Race	Speed in the 2 <sup>nd</sup> half of the race (%)			
	WRs	Olympic finals		
		Medallists	Non-medallists	Finalists
M 800 m	93.9	104.2	103.4	–
W 800 m	98.1	93.3	91.8	–
M 1500 m	102.3	104.3	103.3	101.2
W 1500 m	95.7	109.0	107.6	104.9
M 5 km	101.3	105.7	101.6	97.8
W 5 km	100.0	110.3	109.6	106.3
M 10 km	100.6	104.3	103.4	97.9
W 10 km	102.3	101.9	98.5	95.1

over plots based on the traditional 400-m splits (Figure 3).

Throughout the long-distance races, runners who slowed down in the second half of the race did not decrease their pace more suddenly than medallists and finalists (Table IV). They also displayed an increase of speed during the last lap, albeit smaller than the other finalists (Table IV).

The pacing pattern used by medallists to reduce the size of the field differed from race to race

(Figures 4–7, top), but medallists were consistently faster during the endspurt than other finalists (Table IV). In the 1.5-, 5- and 10-km finals, the race amongst the medallists was decided on the last 400 m by differences in the endspurt (Figures 4–7, bottom).

## Discussion

The current study used high-resolution data gathered in 800- to 10,000-m Olympic track finals to understand pacing in competition where placing is more important than time.

### *Olympic pacing versus World Record strategy*

Except in the women's 10 km, pace in the Olympic finals was less in the opening segment and more variable than the World Record pace. In six of eight finals, pacing did not fit the pattern characteristic of 800-m (positive pacing) and of 1.5- to 10-km (even pacing) World Record performances, respectively (Tucker et al., 2006). The pacing pattern did not systematically vary by distance. De Koning et al. (2011) showed that athletes use different pacing strategies in different disciplines (swimming, running, speed skating) to solve the same problem (comparable finishing times). Our data show that in world-class championships, runners used different pacing strategies even in the same discipline and over the same distance.

### *Constant speed of running*

Constant running speed in middle- and long-distance events does not occur and traditional reporting of 400-m lap splits does not represent the 'true' degree of variation in high-standard finals. Runners usually develop the ability to change speed by using established stochastic training models (fartlek, interval training). Based on our findings, coaches should introduce training models that involve frequent, but small changes in pace.

'Microvariation' seen in Olympic finals represents the complex regulation necessary to balance runners' efforts to keep their pace at the desired level despite growing fatigue, while avoiding a physiologically catastrophic event. For runners performing 10-km races in 42 minutes, Billat, Wesfreid, Kapfer, Koralstein, and Meyer (2006) reported a similar phenomenon. The coefficient of variation (CV) of 10-m-running speed was  $8.7 \pm 2.1\%$ . Billat et al. (2006) suggested that pace variations are an intentional strategy to minimise the physiological strain during severe exercise.

Lap splits in World Record performances suggest smooth and slow transitions of speed. It remains to

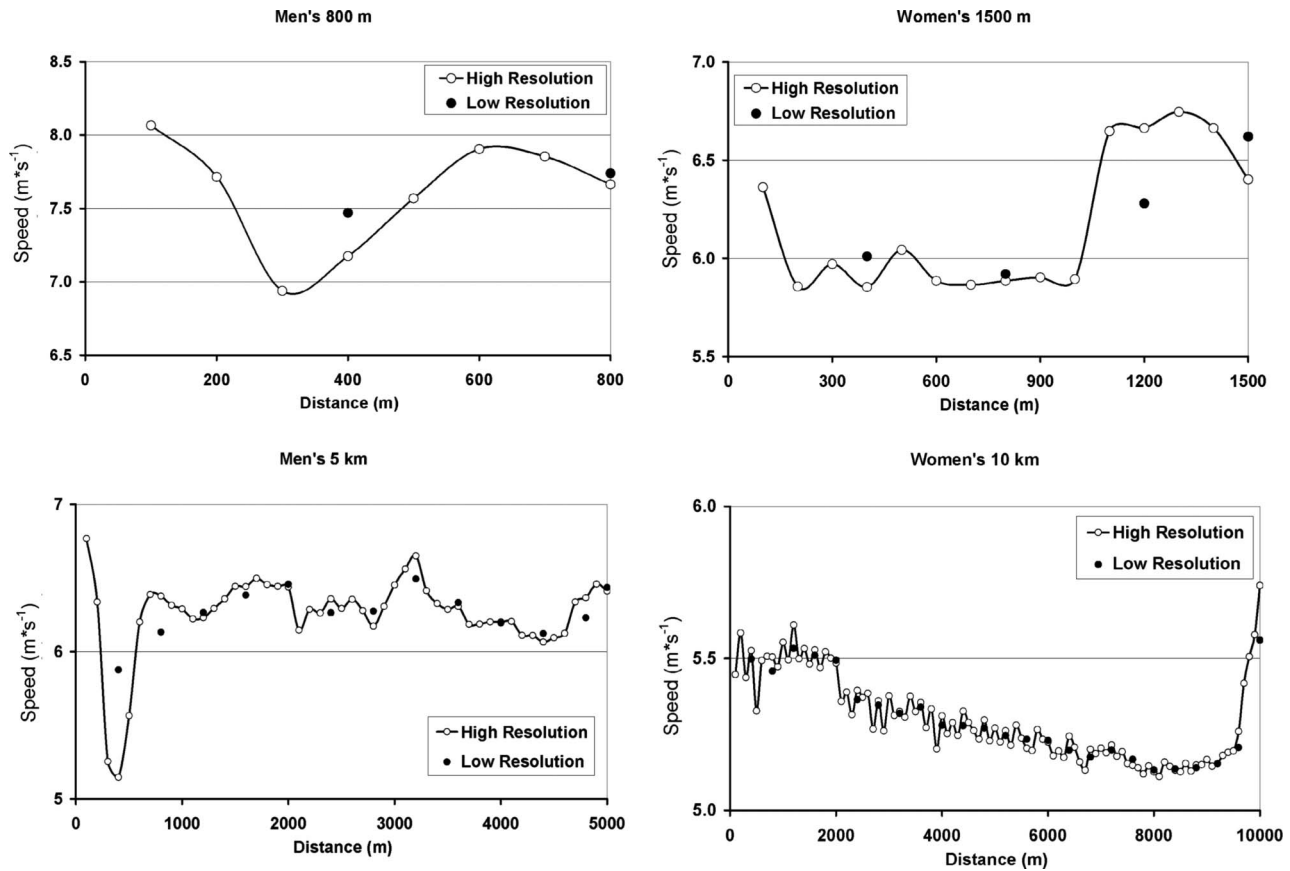


Figure 3. Mean speed of Olympic track finalists at resolutions of 100 m versus 400 m.

Table III. Coefficient of intra-individual variation of running speed during world records (WR) between 1983 and 2008 based on 400-m (800 m, 1500 m) or 1000-m split times (5 km, 10 km) and during Beijing Olympic finals 2008 based on 1000-m, 400-m and 100-m split times (mean, range).

Race	Coefficient of variation (%)			
	WR 400 m/ 1000 m	Olympic finals		
		1000 m	400 m	100 m
M 800 m	4.5 (3.5–6.4)	–	2.5 (0.3–4.2)	5.3 (4.6–5.9)
W 800 m	3.7	–	5.0 (2.6–6.6)	6.2 (3.6–8.1)
M 1500 m	2.9 (2.1–3.8)	–	4.1 (1.8–6.1)	4.9 (3.1–6.3)
W 1500 m	5.5	–	5.1 (2.9–7.0)	6.1 (4.6–7.9)
M 5 km	1.7 (0.5–3.1)	3.2 (1.9–5.6)	4.0 (2.7–5.7)	5.5 (4.7–6.8)
W 5 km	2.5 (1.5–4.0)	9.8 (5.6–12.2)	11.1 (6.7–13.5)	11.4* (7.5–13.5)
M 10 km	1.5 (0.9–2.2)	3.2 (1.5–5.0)	3.6 (1.7–5.1)	4.4 (2.4–6.4)
W 10 km	2.7 (1.5–4.7)	3.1 (1.2–4.9)	3.4 (1.8–5.0)	3.6 (2.1–5.4)

M, Men; W, Women; \*Due to the malfunction of one timing marker in the women's 5-km race, interpolation was used to calculate 100-m split data, resulting in an underestimation of the variation of running speed.

be determined whether in World Records or personal best races, runners also vary their pace every 100 m to the degree seen in Olympic finals.

#### Catastrophic events

Most research into pacing has occurred under controlled or simulated conditions, whereas

competition in the field often forces a variable pacing strategy on the athlete for various reasons. One is to counteract changing external conditions like wind and environmental temperature (Swain, 1997). Another is the requirement of competition, when catching up on a gap is difficult. At the speed typically seen in 5- or 10-km races, shielding by another competitor one metre ahead can reduce the

Table IV. Largest speed reduction throughout the race, and endspurt speed of medallists, finalists and runners who slowed down in the Beijing long-distance events (mean; range).

Medallists				Finalists				Slowed down <sup>1</sup>		
	<i>N</i>	Largest % slow-down <sup>2</sup>	Endspurt speed <sup>3</sup> [%]		<i>N</i>	Largest % slow-down	Endspurt speed [%]	<i>N</i>	Largest % slow-down	Endspurt speed [%]
M 5 km	3	4.4 (3.3–6.0)	103.6 (99.4–108.6)	10	4.3 (1.9–6.7)	102.1 (94.4–107.6)		1	3.7	101.5
W 5 km	3	9.6 (9.5–9.7)	107.1 (105.7–108.7)	12	8.7 (3.0–11.7)	101.4 (96.2–105.4)		0	–	–
M 10 km	3	8.5 (8.2–8.9)	116.1 (113.6–118.9)	22	6.1 (2.3–11.2)	108.6 (102.4–114.4)	10	4.0 (2.8–6.1)	105.3 (94.5–114.3)	
W 10 km	3	3.8 (3.7–4.0)	113.4 (108.3–117.7)	10	3.4 (2.6–4.9)	108.7 (106.1–111.5)	16	3.5 (1.9–7.1)	106.0 (100.2–111.8)	

<sup>1</sup>Runners with a 3% decrease of speed in the second half of the race were defined as runners who had slowed down.  
<sup>2</sup>Largest decrease of speed observed in any 100-m segment versus the previous 100 m, excluding the first half of the race and the last 400 m.  
<sup>3</sup>Last 400 m versus fourth quarter of the race.

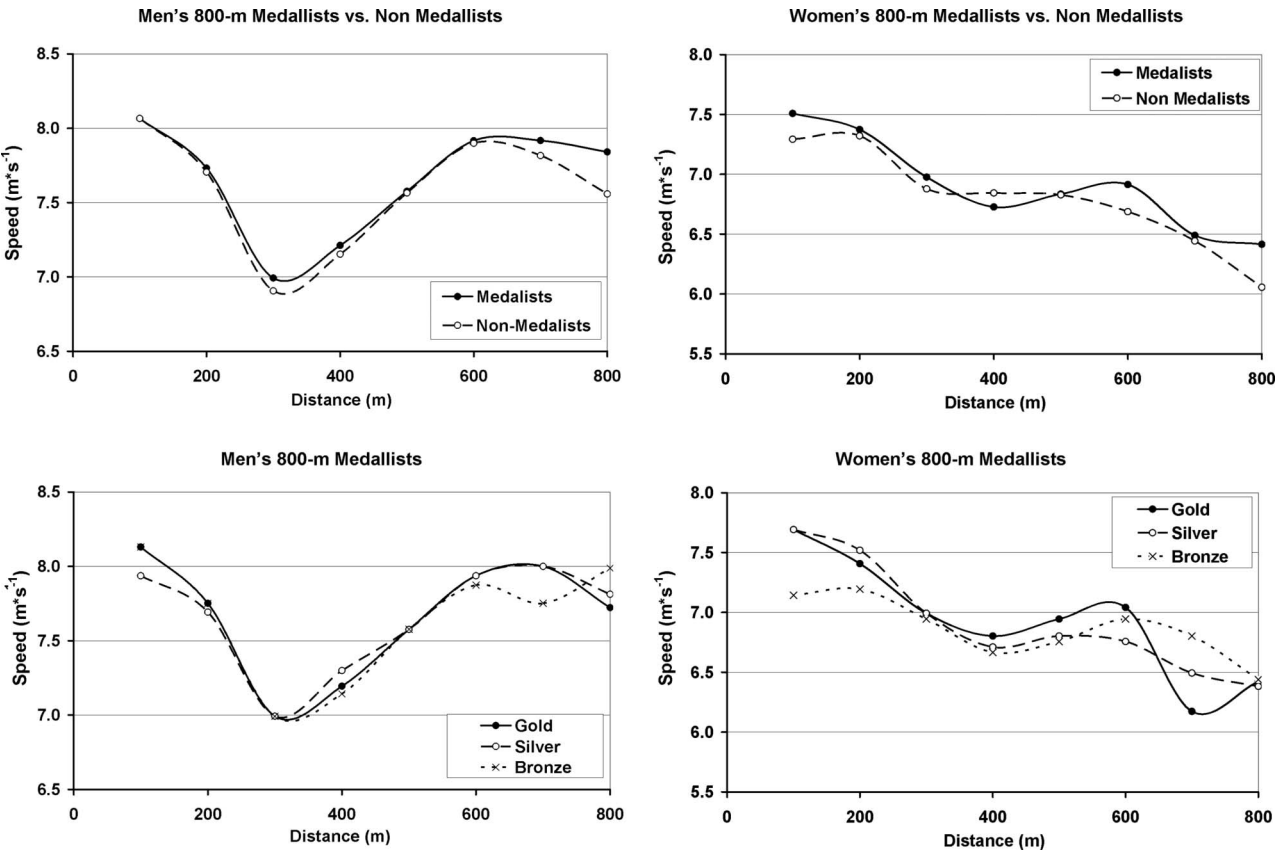


Figure 4. Mean speed of medallists and finalists (top) and individual speed of medallists (bottom) in the 800-m Olympic final.

total energetic cost of running by 6.5% (Pugh, 1971), or decrease lap times by one second (Davies, 1980). In the initial stage of a race, athletes often do not self-select their pace, but rather precisely adjust to the speed enforced by the current group leaders. Olympic finals provide an opportunity for ‘catastrophic events’ (a massive and progressive reduction in speed) to occur. However, runners tend to fall off the pace of the leading group in a controlled fashion and achieve a stable running speed. The mid-race attenuation of pace and accompanying effort in lesser runners does not constitute a catastrophic event, but

an active step to prevent such an event while maintaining the overall pacing strategy. This clearly supports the importance of interactive psychophysiological decision making described in the pacing literature (Swart et al., 2009a, 2009b). Olympic finalists seem to tolerate running the initial kilometre up to 8% faster than their mean pace without becoming overly fatigued (that is, dropping out of the race). Some of these athletes might consider incorporating positively paced running sessions into their training regime to prepare for fast championship races.



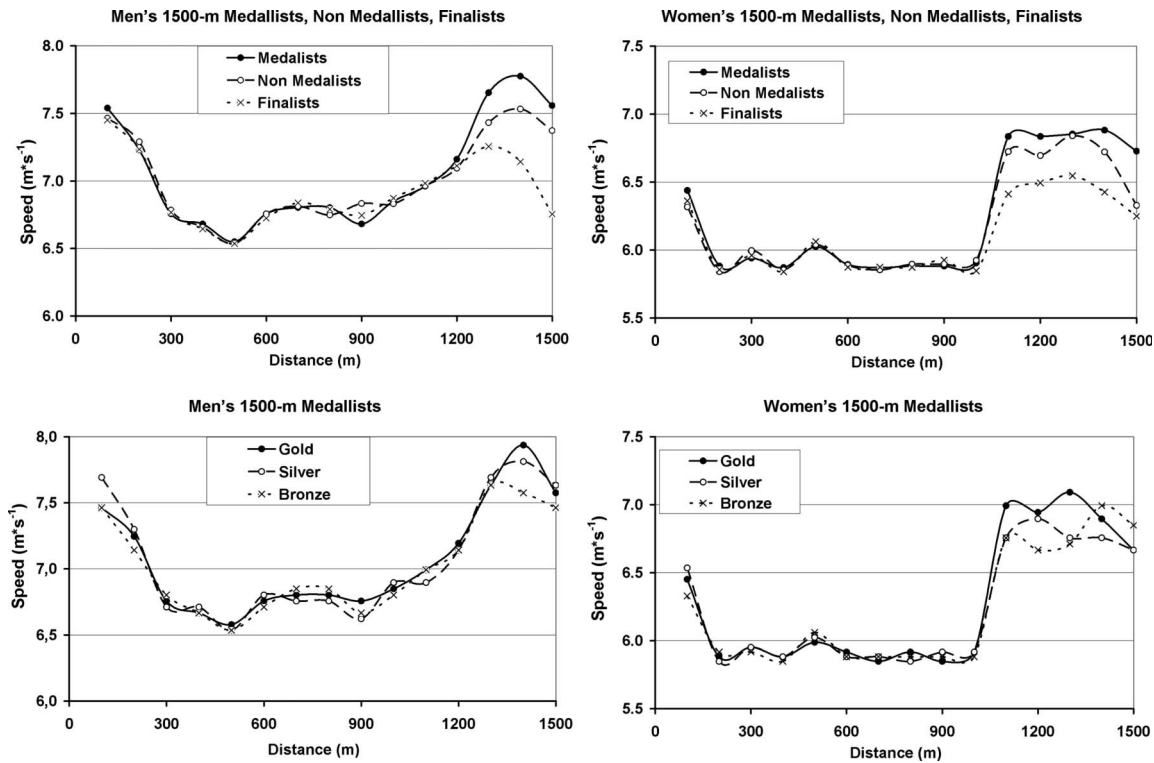


Figure 5. Mean speed of medallists and finalists (top) and individual speed of medallists (bottom) in the 1500-m Olympic final.

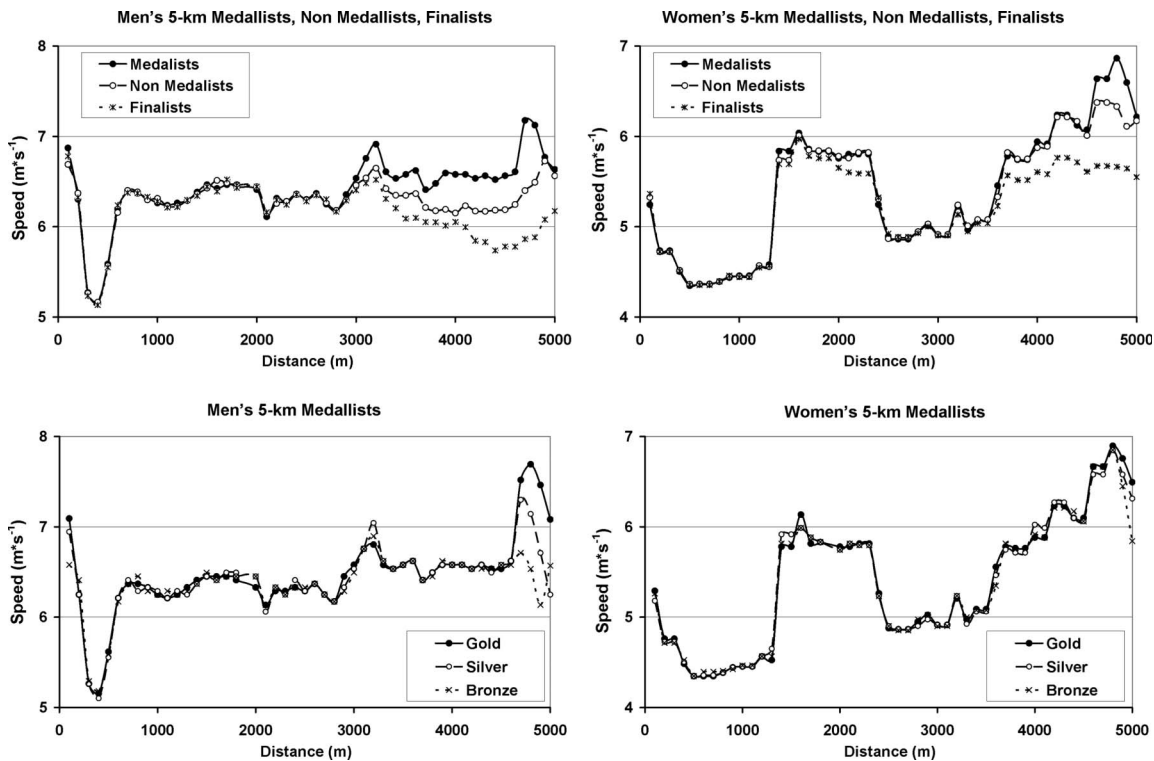


Figure 6. Mean speed of medallists and finalists (top) and individual speed of medallists (bottom) in the 5-km Olympic final.

### Winning strategy

The strategy used by medallists to separate themselves from the field varies. Top contenders use either a continuously high speed (men's and

women's 10 km), a 'break away' in the middle of the event by increasing the pace (at 3 km in the men's 5 km), or a long endspurt after a gradual increase in speed at the end of the race (women's

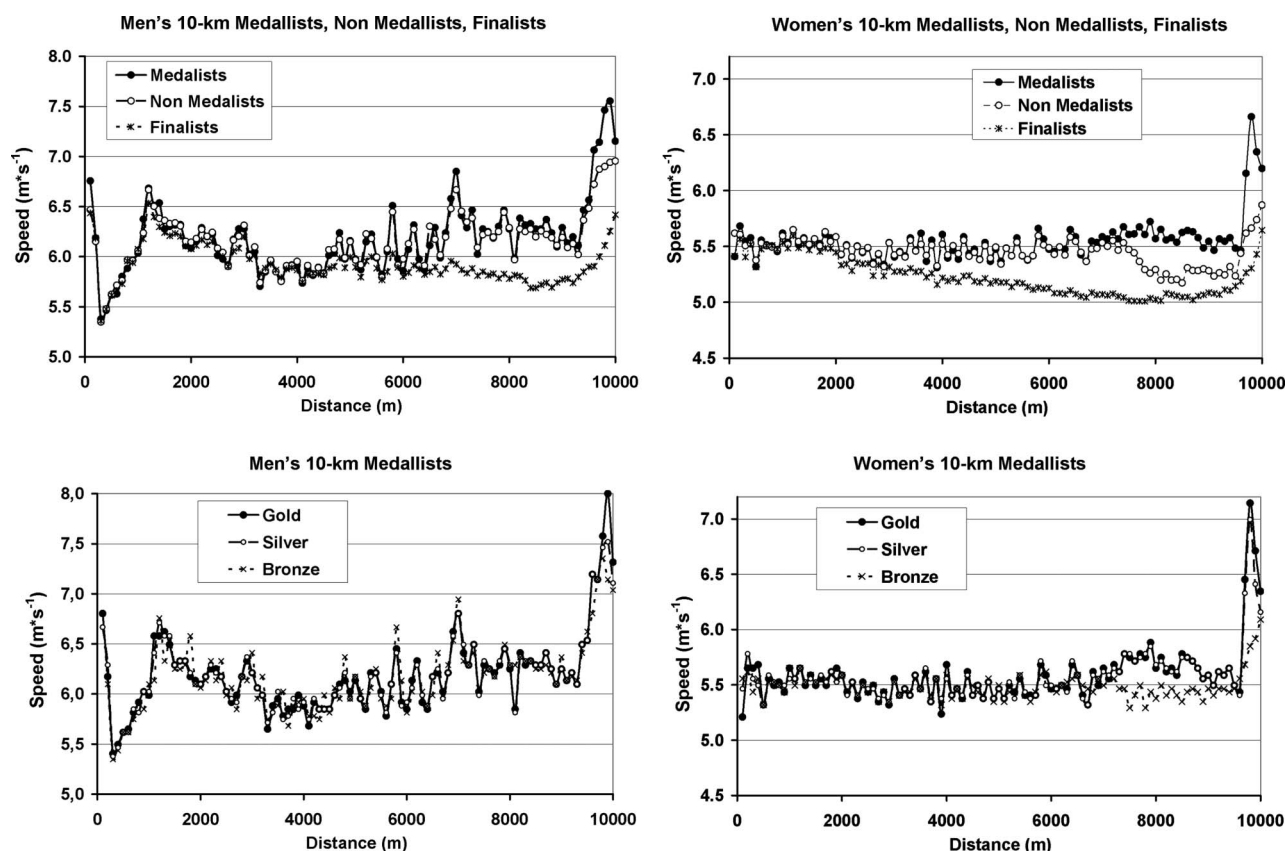


Figure 7. Mean speed of medallists and finalists (top) and individual speed of medallists (bottom) in the 10-km Olympic final.

5 km). Although the athlete may initially envision an overall pacing strategy (creating a template out of experience, expected duration and physiological input) (Foster et al., 2012; Micklewright et al., 2010; Tucker, 2009), this strategy appears to be continuously modified in response to changes in both internal and external factors, among which are tactical considerations. Tactics represent dynamic decisions that can hinder the best possible competitive performance, but conversely, improve the competitive outcome (e.g., a mid-race surge to win the race in less than a personal best time). This tactical nature of races is particularly seen in the slowest race, the women's 5 km.

Amongst the medallists, race outcomes were close, reflecting the high standard of competition. The 1.5- to 10-km finals were decided by differences in the endspurt, with peak speed typically achieved early during the last 400 m. To win a gold medal in the long-distance races, women and men athletes must achieve  $6.9\text{--}7.1\text{ m}\cdot\text{s}^{-1}$  and  $7.7\text{--}8.0\text{ m}\cdot\text{s}^{-1}$ , respectively, which also needs to be considered when designing training programmes.

## Conclusion

Olympic track finalists use pacing strategies different from those in World Record or personal-best races.

Races are highly stochastic, even if they are run at an overall even pace. Also, microvariation in running speed is higher than previously assumed. Dropping off the pace of the leading group is not a catastrophic event, but an active, controlled step designed to prevent such an event. While top contenders use variable pacing strategies to separate themselves from the field, the Gold medal is typically won by the endspurt on the last 400 m. Training programmes that address these specific requirements of high-standard championships should include intervals, microvariation runs, positive-pacing training and speed training.

## Competing interests

No competing interests.

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